RANKINGS

Rankings

Introduction

The New Jersey Comparative Risk Project represents New Jersey's effort to evaluate the relative risk facing the state's people and ecosystems. Its primary question was:

"What is the relative importance of environmental problems in New Jersey?"

It is not the first effort to describe the state's environmental conditions. It may, however, be the most comprehensive report systematically describing numerous physical, biological and chemical threats.

In 1998, then-Commissioner Robert Shinn requested that the Department of Environmental Protection (DEP) carry out a comparison of risks to New Jersey's environment. In this request, Commissioner Shinn asked for the comparative risk approach because of its ability to "provide a basis for comparing environmental issues in a balanced manner using the best possible scientific information." Commissioner Shinn's charge included:

Determine how different environmental issues compare to one another in their negative impacts on human health, ecological quality, and socioeconomic conditions in New Jersey.

Identify the key gaps in our existing knowledge that need to be filled in order to better address the comparison of environmental issues and strategies to deal with those issues.

This report is the result of that charge, and the result of thousands of hours of effort from DEP staff, volunteers, and contractors.

This report is intended as a first step in meeting the following objectives:

Develop a better understanding of New Jersey's environment;

Strengthen the basis for DEP and New Jersey citizens to make choices regarding environmental improvement;

Promote discussion in New Jersey regarding the need for additional action to continue improvement in environmental quality and to address future challenges.

Understanding our environment

DEP was established in 1970 to protect the state's environment. The Department carries out thousands of functions to implement more than a hundred programs. The citizens of New Jersey should be proud that the state has implemented these programs and has gained significant benefit in environmental protection. However, continued progress will not come easily. Continuing growth of the population and economy place increased pressures on our valuable natural resources. In addition, some of our past economic progress came at a price to our land, air, and water. To strengthen the state for its future, we need to address some of those past damages. This comparative risk project report will help New Jersey decisionmakers in that effort.

The New Jersey Department of Environmental Protection (DEP) has produced several assessments of environmental conditions over the past few years. In 1995, DEP produced an assessment as a part of its participation in the National Environmental Performance Partnership System with EPA. That project initially focused on air and water quality programs that were direct partnerships between New Jersey and EPA. New Jersey since expanded the scope of its self assessment and Performance Partnership participation to include almost all of its programs, including those that have no direct federal support. In 1998, New Jersey released its first State of the Environment Report. That report highlighted some of the improvements that have taken place during three decades of DEP action. The most important difference between this comparative risk report and previous efforts is the structure used in carrying out the assessments. The NJCRP report is designed so that different issues can be considered and compared.

Because of the maturity of many programs and the opportunities for program changes offered by DEP's own internal planning and management policies, comparative risk is particularly useful. One requirement for an optimal planning process is a solid understanding of the relative magnitude of negative impacts from different environmental issues. From this understanding, the state can work together with its federal partners to ensure that programs address the most significant environmental threats. This comparative risk project will help New Jersey develop future Performance Partnership Agreements with the EPA as well as inform internal strategic planning and management efforts.

The results of this comparative risk project should also enhance future sustainability projects. New Jersey is a national leader in the use of sustainability principles for implementing state policies. Recent examples include the New Jersey Future project ("sustainable state"), the Sustainable State Institute and New Jersey's identification of a greenhouse gas emissions reduction target.

But where to next? There are literally hundreds of stresses to our environment occurring to varying degrees at many locations across the state. How do we choose? How do we focus our resources? How do we decide where to place our efforts? The circulation of this document represents the first opportunity to promote discussion. We look forward to receiving your feedback with regards to the analysis that we undertook to better understand New Jersey's environment. *

The next sections describe very briefly the way in which the project produced rankings (details of the process of analyzing impacts, on which rankings were ultimately based, are discussed in the "Analyses" section of the report), presents the overall rankings by each of the Technical Working Groups, and discusses caveats about the rankings.**

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** Readers should note that the authors' insights on any particular issue write-ups are theirs alone and do not necessarily reflect a consensus view of all persons involved in the Comparative Risk Project. The technical work was subjected to peer review to ensure that it reflects generally accepted knowledge. The Co-Chairs sincerely appreciate the time, effort and dedication put forth by the technical working groups in the research, writing and development of the numerous issue write-ups in the Comparative Risk Report. The results, conclusions and recommendations of this study reflect the knowledge and judgment of the project participants who were selected based on their respective expertise, interest in environmental issues and diverse perspectives.

Assessing Impacts

Both natural and human-caused factors can influence the health of human beings and the environment. These factors, referred to as *stressors*, come in three major types—biological, chemical, or physical. Stressors can affect human health, influence ecological quality, create socioeconomic impacts, or result in any combination of the three. (Stressors' benefits were not estimated in this project.) Sources of stressors can range from industrial activities to agricultural practices to personal behaviors to natural processes. Stressors are the conceptual linkage between cause and effect, between sources and the health, ecological, or socioeconomic impacts that may result.

How were the stressors evaluated and scored?

The Human Health, Ecological Quality, and Socioeconomic Technical Working Groups gathered and organized information about the stressors and their effects. The identity and nature of each stressor, the level of the stressor present in New Jersey, and the adverse effects at given amounts were described (see Appendix 2 for the templates used in these analyses; the "Analyses" section describes the impact analysis process in more detail.) All three TWGs then applied their own specific criteria for evaluating and scoring the stressors:

Human health criteria

- Severity of health impacts
- Size of population at risk
- Discrete communities affected

Ecological criteria

- Severity/irreversibility of ecological impacts
- Frequency of ecological impacts
- Magnitude of ecological impacts

Socioeconomic criteria

- Severity of socioeconomic impacts
- Duration/Irreversibility of socioeconomic impacts
- Scale of socioeconomic impacts

For each stressor, scores for each criterion were combined within each TWG to derive single scores for human health risk, ecological risk, and socioeconomic risk. In some cases where very little information exists, or the stressor was judged to present too little potential for impact to support a full scale-assessment, a "short report" was developed in lieu of a full risk characterization. The ranks assigned to each stressor reflect a relative assessment of risk (e.g., high, medium, low) rather than an absolute estimate of the inherent risk (e.g., one-in-a-million cancer risk).

Designing the risk ranking

There were many challenges encountered in developing the risk rankings. However, despite the caveats, there was a large enough range of impacts among the different stressors that the rankings were reasonable representations of *relative* risks in New Jersey. Accomplishing the ranking required each TWG to determine the most appropriate mechanism for combining and summarizing risk factors in a useful fashion. The Analyses section includes a description of the ranking details for each TWG.

This report does **not** include a single ranking of stressors that combines human health, ecological quality and socioeconomic impacts. The Steering Committee considered this possibility and decided that more information would be lost through the combination of information than would be gained by developing the single ranking. The degree of agreement and disagreement among the TWGs' rankings can be seen in Table 2. It compares rankings offered by the Health and Ecological TWGs for stressors that both groups analyzed (several stressors, such as acrolein and invasive plants, respectively, were done by only one group; stressors ranking low for both groups are not shown in the table). Since socioeconomic impacts are often secondary effects based on primary human health and ecological impacts, they tend to reinforce the patterns shown in the table, making a third dimension unnecessary. Note that only about a third of the stressors compared are within one rank across these two TWGs, which is understandable since the two groups were looking at qualitatively different impacts in most cases. But this disparity underlines the value in avoiding a single integrated ranking.

Table 2. Comparison of Human Health and Ecological Rankings

ECOLOGICAL RANKS	HUMAN HEALTH RANKS				
	High	**Medium-High**	**Medium**	**Medium-Low**	**Low**
High					
Medium-High			Mercury Ultraviolet radiation		
Medium	Lead PCBs		Endocrine disruptors		Cadmium Nitrogen pollution
Medium-Low		Dioxins/furans	Arsenic Chromium		
Low	Ozone (ground level)	VOCs (Health carcinogenic)		VOCs (Health non-carcino-genic)	

The following pages show the results of the rankings for Human Health, Ecological Quality, and Socioeconomic impacts, respectively. Each ranking table provides the following information.

- Overall ranking: This is scored in five categories, from High to Low. Stressors are listed alphabetically within each ranking category.
- Uncertainty: This represents the degree of confidence that the Working Group has about the overall ranking, from High to Low.
- Trend: This shows whether Working Groups expect the stressor's impacts in New Jersey to get worse, improve, or stay the same.
- Catastrophic Potential: This represents the possibility of a very large impact due to a single accident or some other unusual event (which may not actually occur), ranked from high to low.

Ranking Results

Human Health Impacts

Overall findings/ highlights

Six stressors are ranked as high risks to New Jersey health. These are secondhand tobacco smoke, radon, ozone, PCBs, airborne particulate matter, and lead. In the cases of secondhand tobacco smoke, radon, and PCBs, the potential for cancer is approximately one thousand additional cases each year. For many of these stressors, children are among the most "at risk" populations in the state because they are more susceptible to statewide exposure levels.

Ozone and lead do not lead to cancer, but thousands of children are at risk for neurological development problems from lead exposure, and hundreds of thousands of New Jersey residents may suffer respiratory effects from elevated atmospheric ozone. All residents of the state are potentially exposed to harmful levels of ozone. Children have the highest risk from exposure to ozone because they have developing respiratory systems, breathe greater amounts of air per body mass as compared to adults, and are active outside during the summertime when ozone levels are at their highest. Adults and children with respiratory illnesses, such as asthma, bronchitis and emphysema, can experience a reduction in lung function and increased respiratory symptoms when exposed to relatively low ozone levels. Precursor emissions should decrease as a result of the actions contained in the current State Implementation Plan for meeting the ozone National Ambient Air Quality Standard, but this will not be enough to meet either the 1-hour or the 8-hour ozone standard. The overall decrease in the number of ozone exceedance days since the 1970s can be attributed to reduced emissions from automobiles and industrial sources, and control of emissions of gasoline during refueling.

The presence of lead contamination in major environmental media (air, water, soil/ sediments), as well as its historic presence in consumer products such as paint, ceramics, plumbing supplies, and canned goods, currently results in a low, but pervasive background prevalence in the New Jersey population. Children represent sensitive subpopulations by virtue of experiencing increased exposure to contaminated soil and dust, and greater sensitivity to neurological impairment at relatively low blood lead levels. Among children, those with low socioeconomic status are at even greater risk, due to a higher probability of living in housing with peeling lead-based paint and in neighborhoods with historical soil contamination from flaking lead-based paint and heavy vehicular traffic using leaded gasoline, and to increased risk of poor nutritional status (which increases lead absorption).

For secondhand tobacco smoke and radon, the sources are indoors and largely in the home. The potential for reducing these risks hinges on the ability to change personal behaviors in the case of environmental tobacco smoke and the encouragement of home testing and modifications for radon. Tobacco smoke exposure occurs among all populations throughout New Jersey with the age group of 18-24 having the highest percentage of usage (29.6% smoking). Children's lungs are even more susceptible to harmful effects than those of adults. Several recent studies link secondhand tobacco smoke with increased incidence and prevalence of asthma and increased severity of asthmatic symptoms in children of mothers who smoke heavily. These respiratory illnesses in childhood may contribute to small, but significant lung function reductions associated with exposure to tobacco smoke in adults. In the 1970's, New Jersey was a leader in restricting the non-smoker's exposure to tobacco smoke. But current state laws only require that restaurants have a non-smoking section, do not prohibit smoking in the workplace, and do not require any separation between smoking and non-smoking areas, although smoking in publicplaces is prohibited. All New Jersey citizens are also at high risk from radon. The entire state population is exposed to radon in the outdoor air, and large regions of the state are at increased risk for significantly elevated radon levels in their homes. There are no requirements that homeowners must test their homes for radon, but it has become standard practice in real estate transactions and state law regulates radon hazards for new construction.

Polychlorinated biphenyls (PCBs) exposures (as for lead exposures) are largely the result of historical use of the chemicals; in these cases, current exposures are significant but decreasing. The health effects associated with exposure to PCBs include breast cancer, non-Hodgkin's lymphomas, liver and gall bladder cancers, pancreatic cancer, decreased thyroid hormone, and prenatal effects that influence postnatal neurodevelopment. The populations most at risk are fish consumers, and infants breast-fed by women who consumed contaminated fish while pregnant. The decreasing use of products containing PCBs along with fish consumption advisories will lead to an improving trend.

The sources of particulate matter (PM) are both natural and human-made. Particulate matter that is smaller than 2.5 micrometers in diameter is most likely to affect human health. Health effects include exacerbation of preexisting cardiopulmonary disease like asthma and other forms of airway obstructive disease, reduced lung function, alterations in the body's defense system against inhaled material, and damage to lung tissue. Susceptible populations include those with preexisting cardiopulmonary disease, the young, the elderly and smokers. Researchers have found associations between increased PM and increased mortality and morbidity. The entire population of New Jersey is exposed to levels that are estimated to cause adverse health effects. Since a significant portion of PM comes from coal burning power plants, and the U.S. Environmental Protection Agency is not supporting the Clean Air Act New Source Performance Standards (NSPS), it is unlikely that there will be any appreciable decline in levels of PM in the near future. Lack of control of motor vehicle particulate emissions and the increase in vehicle miles driven contribute to levels of PM in New Jersey.

One biological and four chemical stressors fall in the "Medium-High" risk category. Four of the five (radium, carbon monoxide in indoor air, indoor microbial asthma inducers, and carcinogenic VOCs) are airborne contaminants. For the remaining stressor, dioxins and furans, food is the primary means of exposure. Most of the impacts from the airborne stressors are the result of indoor exposure. The biological stressor, indoor microbial asthma inducers, reflects the fact that many asthma inducers are found in the home. Increasing awareness of the links between respiratory problems and these relatively high-risk environmental stressors has led to increasing concerns for public health.

The "Medium" ranked issues include many chemical pollutants that are currently released into the environment. For most of these, there have been reductions in the exposures, but their continued releases are the result of dispersed sources that are difficult to manage. Some of the medium ranked chemicals (1,3-butadiene, mercury and NOx) result from vehicle and utility combustion of fossil fuels.

Some stressors are ranked as having relatively low impacts because of successful regulation and significant public investment. Some chemical stressors, such as SOx, are found in much lower concentrations than in the past as a result of restrictions on the emissions from large industrial sources. MTBE contaminates ground water because of its recent introduction as a gasoline additive, but currently poses a low risk.

Table 3. Statewide Human Health Rankings

Stressor Name	Ranking	Uncertainty	Trend	Catastrophic Potential
Lead	High	Low	Better	Low
Ozone (ground level)	High	Medium	Better	Low
Particulate matter	High	Medium	Same	Low
Polychlorinated biphenyls (PCBs)	High	Medium	Better	Low
Radon	High	Low	Better	Low
Secondhand tobacco smoke	High	Medium	Better	Low
Carbon monoxide (CO) - indoor	Medium-High	Medium	Better	Low
Dioxins/Furans	Medium-High	Medium	Better	Low
Indoor asthma inducers	Medium-High	High	Worse	Low
Pesticides-Indoor	Medium-High	High	Same	High
Radium	Medium-High	Medium-High	Same	Low
Volatile Organic Compounds (VOCs)-carcinogenic	Medium-High	Medium	Better	Low
1,3-butadiene	Medium	Medium-High	Better	Low
Acrolein	Medium	Medium-High	Same	Low
Arsenic	Medium	Medium	Better	Low
Benzene	Medium	Medium	Better	Low
Chromium	Medium	High	Better	Low
Disinfection byproducts	Medium	Medium	Better	Low
Endocrine Disruptors	Medium	High	Worse	Medium
Formaldehyde	Medium	Medium	Same	Low
Legionella	Medium	High	Same	Low
Mercury	Medium	High	Better	Low
Nitrogen oxides (NOx)	Medium	Medium-Low	Same	Low
Pesticides-food	Medium	High	Better	Low
Pesticides-outdoor	Medium	High	Better	Medium-High
Pesticides-water	Medium	High	Better	Low
Ultraviolet radiation	Medium	Low	Worse	Low
Waterborne pathogens - recreational water	Medium	Medium	Same	Low
Airborne pathogens	Medium-Low	High	Same	Low
Carbon monoxide (CO) outdoor	Medium-Low	Medium	Better	Low
Cryptosporidium- recreational water	Medium-Low	High	Same	Low
Sulfur oxides (SOx)/Sulfates	Medium-Low	Medium-Low	Better	Low
Volatile Organic Compounds (VOCs) non-carcinogenic	Medium-Low	Medium-Low	Better	Low
Cadmium	Low	Medium	Same	Low
Cryptosporidium-drinking water	Low	High	Better	Low
Extremely low frequency/Electromagenetic fields	Low	High	Better	Low
Greenhouse gases	Low	High	Same	High
Hanta virus	Low	Low	Same	Low
Indoor microbial air pollution	Low	High	Same	Low
Lyme disease	Low	Medium	Better	Low
Methyl tertiary butyl ether (MTBE)	Low	High	Better	Low
Nickel	Low	Medium	Same	Low
Nitrogen pollution (water)	Low	Medium	Better	Low
Noise	Low	High	Better	Low
Pfiesteria	Low	Low	Same	Low
Polycyclic Aromatic Hydrocarbons (PAHs)	Low	High	Same	Low
Radionuclides	Low	Low	Same	Low
Waterborne pathogens-drinking water	Low	Medium-High	Same	Low
West Nile virus	Low	Medium-High	Better	Low

Ecological Quality Impacts

Overall findings

Physical alteration of habitat stands out in the ranking as the most compelling ecological problem in New Jersey. Virtually the entire state is at risk from ongoing fragmentation and loss of habitat, which received significantly higher scores than other highly ranked issues. Birds and other species that require large expanses of intact habitat are especially at risk. Roads and other developments force changes in wildlife mobility patterns, promote the dominance of more disturbance-tolerant nuisance species, and increase the proportion of impervious (e.g., pavement) surface. The rate of increase in impervious surface area alone represents a significant risk to ecosystems. The resulting change in the quantity and quality of storm runoff alters natural stream flow patterns, increases erosion, and further degrades habitat. A continuing cycle of habitat degradation compounded by a proliferation of additional, related stressors (e.g., invasive species, inadvertent mortality, noise, nutrients, etc.), leading to further degradation, represents a serious and overarching threat to New Jersey ecosystems.

Ultraviolet (UV) radiation from the sun, which can be increased by human-caused depletion of stratospheric ozone, ranked medium-high. Like people, plants and wildlife can suffer adverse effects as a result of exposure to UV-B radiation, and all species in all parts of the state are susceptible. Of particular concern are the effects of UV radiation on the lowest levels of the food chain. Observed effects on marine plankton, for example, may carry significant repercussions, potentially affecting many species in a myriad of ways. While human health effects from UV radiation can be somewhat controlled via avoidance and treatment, terrestrial and aquatic ecosystems cannot be protected.

Our historic use of chemicals continues to threaten ecological communities. Though banned many years ago, chlorinated pesticides such as DDT and chlordane continue to cause adverse effects in wildlife. The ability of these chemicals to persist for decades in the soils and sediments ensures that ecological exposures will continue for years to come. Levels are declining, however, and bird populations have increased in the years since DDT and chlordane were banned in 1972 and 1988, respectively. For other chemical stressors, notably mercury and lead, emissions to the environment continue. As with UV radiation, human health risk can be reduced with successful education and avoidance efforts, but ecological communities remain at risk. As long as these metals continue to be discharged (even under increasingly stringent regulations), environmental exposure will continue to cause developmental and other abnormalities in animals.

Much more difficult to control than chemicals, a number of biological stressors pose medium to high risks for New Jersey ecosystems. A number of these are considered pests due to their overabundance. White-tailed deer, Canada geese, and starlings—species which flourish in disturbed or urbanized landscapes—edge out other species or disrupt natural ecosystem processes, exacerbating the effects of habitat loss and other stressors. Invasive plants, such as the multiflora rose and purple loosestrife, have similarly spread to nuisance proportions in many areas of the state. Most of these plants are non-natives, and some continue to be sold as ornamentals. Like the animals, they tend to adapt to a wide range of conditions, outcompeting other plants and consequently altering the abundance and diversity of natural plant communities and the wildlife that depend on them.

The hemlock woolly adelgid, an aphid-like insect pest, poses a potentially catastrophic risk to New Jersey hemlock forests. All hemlock forests in the state are at risk from the non-native adelgid and more than 90% have already been infested to some extent. Once trees have become defoliated, they rarely recover. Unless the adelgid can be controlled (introduction of exotic predators offers some hope), the current infestation will undoubtedly lead to a total loss of hemlock trees, along with serious ecological consequences.

In the past, the recognition of the relationship between stressors and negative ecological impacts has resulted in actions to reduce risk. The rate of chemical releases to the environment has been substantially reduced, and environmental concentrations are showing improvement. In time, ecological effects will be reduced as a result. The connections between physical and biological stressors and ecosystem health are not as broadly recognized, nor do they arouse similar levels of public concern. This general lack of awareness combined with ongoing rates of physical and biological stress compounds the risks associated with widespread land use change. A number of moderate to high ranking physical or biological stressors are directly or indirectly linked to the rate and magnitude of habitat disturbance in New Jersey. A focus on this broad issue represents a useful starting point for reducing ecological risk statewide.

Table 4. Statewide Ecological Quality Rankings

Stressor Name	Ranking	Uncertainty	Trend	Catastrophic Potential
Habitat fragmentation	High	Low	Same	Low
Habitat loss	High	Medium	Same	Low
Hemlock woolly adelgid	Medium-High	Low	Better	High
Increase in impervious surface	Medium-High	Low	Same	Medium-High
Mercury	Medium-High	Medium	Same	Low
Pesticides-historic use	Medium-High	High	Better	Low
Ultraviolet radiation	Medium-High	Medium	Worse	Low
Cadmium	Medium	Medium	Same	Low
Catastrophic radioactive release	Medium	Low	Same	Low
Deer	Medium	Medium-Low	Same	Low
Endocrine disruptors	Medium	Medium	Same	Low
Geese	Medium	Medium	Worse	Low
Inadvertent animal mortality	Medium	Medium	Better	High
Invasive plants *	Medium	Medium	Worse	Low
Lead	Medium	Medium	Worse	Low
Nitrogen pollution (water)	Medium	Medium	Same	Low
Overharvesting (marine)	Medium	Medium	Better	Medium
Petroleum spills	Medium	Medium	Same	High
Phosphorus	Medium	Low	Worse	Low
Phthalates	Medium	High	Same	Low
Polychlorinated biphenyls(PCB)	Medium	Medium	Better	Low
Starlings	Medium	Medium	Same	Low
Acid precipitation	Medium-Low	Medium	Better	Low
Arsenic	Medium-Low	High	Same	Low
Brown tide	Medium-Low	Low	Worse	High
Chromium	Medium-Low	Medium-High	Same	Low
Copper	Medium-Low	High	Worse	Low
Dioxins/Furans	Medium-Low	Medium	Better	Low
Dredging	Medium-Low	Medium	Same	Low
Greenhouse gases	Medium-Low	High	Worse	Low
Nickel	Medium-Low	High	Same	Low
Noise	Medium-Low	High	Worse	Low
Off-road vehicles	Medium-Low	Medium	Same	Low
Pesticides-present use	Medium-Low	High	Better	Low
Polycyclic aromatic hydrocarbons (PAHs)	Medium-Low	Medium-High	Same	Low
Tin	Medium-Low	Medium	Better	Low
Water overuse	Medium-Low	Medium	Worse	Low
West Nile virus	Medium-Low	Medium	Worse	Low
Zinc	Medium-Low	Medium	Same	Low
Asian longhorned beetle	Low	Medium	Better	Medium-Low
Blue-green algae	Low	Low	Same	Low
Channelization	Low	Medium-Low	Better	Low
Dermo parasite in oysters	Low	Low	Worse	Low
EHD virus in deer	Low	Low	Same	Low
Extremely low frequency/Electromagnetic fields	Low	Medium-High	Better	Low
Floatables	Low	Medium	Better	Low
Genetically modified organisms (GMOs)	Low	High	Worse	Low
Green/red tides	Low	Medium-Low	Same	Low
Light pollution	Low	High	Worse	Low
MSX parasite in oysters	Low	Medium-Low	Same	Medium
Ozone (ground level)	Low	Low	Better	Low
Pets as predators	Low	High	Same	Low
Pfiesteria	Low	Low	Same	Low
QPX parasite in shellfish	Low	High	Same	Medium-Low
Road Salt	Low	High	Better	Low
Thermal pollution	Low	Low	Same	Low
Volatile Organic Compounds (VOCs)	Low	Medium-Low	Same	Low
Zebra Mussels	Low	Medium	Worse	Medium

* Summary of separate analyses of impacts of ten plant species.

Socioeconomic Impacts

Overall Findings

Given the criteria defined for this analysis, land use change has by far the most extensive socioeconomic implications. As the wealth and workforce migrate out of city centers, remaining urban residents are subject to increasing poverty rates and neighborhood deterioration. Meanwhile, suburban dwellers experience disproportionate transportation and infrastructure costs as a result of their vehicle-centered communities. Statewide, urban property value losses total in the billions. Employment is also affected as suburban development takes jobs out of downtown areas where lower-income city residents cannot travel to them. Other impacts are more difficult to quantify, but land use change is also associated with negative aesthetic and psychological impacts, including a weakened sense of community and increased stress levels. Benefits of land use change, though not estimated in this project, are undoubtedly substantial, but associated negative impacts may not be inevitable.

The risks of lead are even better documented. Virtually all of the state is potentially at risk via lead levels in soils and in the paint used in older structures. Medical costs related to lead in New Jersey may reach $774 million annually, according to national estimates. Costs for the removal of lead paint in homes and other buildings add to the economic burden. There is also a significant psychological component to the risks from lead. The risks of lead poisoning are well publicized and families living in older homes may experience high levels of concern, particularly when they are financially or otherwise unable to remediate their homes.

Common to the stressors judged "medium-high risk" is the ability to assign a relatively high dollar figure to the damages associated with the stressor. Generally speaking, high medical costs attributable to the stressor are a primary risk factor, along with an associated psychological (worry) component. Examples include excess cancers due to environmental tobacco smoke and ultraviolet radiation. Medical and damage costs associated with indoor microbial concentrations—including costs to address "sick building syndrome"—are in the hundreds of millions. In a few cases, property damage drives risk rather than medical costs. Damages associated with white-tailed deer, for example, may be as much as $160 million annually, and include crop and garden damage, and vehicle collisions. A number of specific chemical stressors, such as arsenic and PCBs, can depress both property values and employment. The socioeconomic impacts of phosphorus center on the significant loss of aesthetics associated with the eutrophication of New Jersey lakes.

The threshold values established at the outset of the analysis played a key role in the ultimate determination of stressors that pose "high" socioeconomic risks. In order for a stressor to achieve a rating other than "low" it had to exceed the specific benchmarks established for impacts on property values, employment, or damage costs (see Analyses section). It is important to note that these benchmarks were set based on significance at a statewide level. In the case of damage costs, for example, a stressor would have to have documented or predictable impacts exceeding $16 million to rate above a "low." Consequently, stressors judged to be low risk may have significant localized impacts, or a statewide impact for which there is insufficient evidence for making a determination about dollar costs. Information to help flesh out these types of subtleties in the ranking can be found in the full analyses for each stressor.

Table 5. Statewide Socioeconomic Impact Rankings

Stressor Name	Ranking	Uncertainty	Trend	Catastrophic Potential
Land use change	High	High	Worse	Medium
Lead	High	High	Better	Low
Arsenic	Medium-High	Medium-High	Better	Low
Deer	Medium-High	Medium-High	Better	Low
Indoor asthma inducers	Medium-High	Medium-High	Same	Low
Particulate matter	Medium-High	Medium-High	Same	Low
Pesticides	Medium-High	Medium-High	Better	Medium
Petroleum spills	Medium-High	Medium-High	Better	Medium
Phosphorus	Medium-High	Medium-High	Same	Low
Polychlorinated biphenyls (PCBs)	Medium-High	Medium-High	Better	Low
Secondhand tobacco smoke	Medium-High	Medium-High	Better	Low
Ultraviolet radiation	Medium-High	Medium-High	Worse	Low
Dioxins/Furans	Medium	Medium	Better	Low
Endocrine disruptors	Medium	Medium-High	Worse	Medium
Inadvertent animal mortality	Medium	Medium	Same	Low
Indoor microbial air pollution	Medium	High	Same	Low
Invasive plants	Medium	Medium	Worse	Low
Noise	Medium	Medium	Worse	Low
Ozone (ground level)	Medium	Medium	Better	Low
Polycyclic aromatic hydrocarbons (PAHs)	Medium	Medium	Same	Low
Radon	Medium	Medium	Better	Low
Sulfur oxides (SOx)	Medium	Medium	Better	Low
Water overuse	Medium	Medium	Worse	Low
1,3-butadiene	Medium-Low	Medium-Low	Better	Low
Acid precipitation	Medium-Low	Medium	Better	Low
Acrolein	Medium-Low	Medium-Low	Same	Low
Catastrophic radioactive release	Medium-Low	Medium-Low	Same	Medium
Chromium	Medium-Low	Medium-Low	Better	Low
Dermo and MSX parasites in oysters	Medium-Low	Medium-Low	Better	Low
ELF/EMF	Medium-Low	Medium-Low	Same	Low
Floatables	Medium-Low	Medium-Low	Better	Low
Formaldehyde	Medium-Low	Medium-Low	Same	Low
Greenhouse gases	Medium-Low	Medium-Low	Worse	Low
Hemlock woolly adelgid	Medium-Low	Medium-Low	Worse	Low
Light pollution	Medium-Low	Medium-Low	Worse	Low
Mercury	Medium-Low	Medium-Low	Better	Low
Methyl tertiary butyl ether (MTBE)	Medium-Low	Medium-Low	Better	Low
Volatile organic compounds (VOCs)	Medium-Low	Medium-Low	Better	Low
Waterborne pathogens	Medium-Low	Medium-Low	Worse	Low

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Table 5. Statewide Socioeconomic Impact Rankings (continued)

Stressor Name	Ranking	Uncertainty	Trend	Catastrophic Potential
Asian longhorned beetle	Low	Low	Worse	Medium
Benzene	Low	Low	Better	Low
Brown tide	Low	Low	Worse	Low
Cadmium	Low	Medium-Low	Same	Low
Carbon monoxide (CO)	Low	Low	Better	Low
Copper	Low	Low	Worse	Low
Cryptosporidium	Low	Low	Same	Medium
Disinfection byproducts	Low	Low	Better	Low
Dredging	Low	Low	Same	Low
EHD virus in deer	Low	Low	Same	Low
Geese	Low	Low	Worse	Low
Genetically modified organisms (GMOs)	Low	Medium	Worse	Medium
Green/red tides	Low	Low	Same	Low
Hanta virus	Low	Low	Same	Low
Legionella	Low	Low	Same	Low
Nickel	Low	Low	Same	Low
Nitrogen Oxides (NOx)	Low	Low	Same	Low
Nitrogen pollution (water)	Low	Low	Same	Low
Off-road vehicles	Low	Low	Worse	Low
Overharvesting (marine)	Low	Low	Better	Low
Pets as predators	Low	Low	Worse	Low
Pfiesteria	Low	Low	Same	Low
QPX parasite in shellfish	Low	Low	Same	Low
Radium	Low	Medium	Same	Low
Road salt	Low	Low	Better	Low
Starlings	Low	Low	Worse	Low
Thermal pollution	Low	Low	Same	Low
Tin	Low	Low	Better	Low
West Nile virus	Low	Low	Better	Low
Zebra mussels	Low	Low	Worse	Low
Zinc	Low	Low	Same	Low

Understanding Risk Rankings

The Comparative Risk Approach

Historical Perspective

In 1987, the United States Environmental Protection Agency (EPA) released a report ranking the relative risks from 31 environmental problems. The report, titled *Unfinished Business,* attempted to systematically describe the risks associated with these issues so that senior leadership could better focus its efforts to protect human health and the environment. Since that initial project, dozens of states and localities have adapted EPA's approach in order to develop a better understanding of their own environmental problems.

The *Unfinished Business* project and others that followed were innovative in their comparison of threats across program areas. The premise was that a comparison of relative risk would allow federal and state environmental agencies to focus attention and resources where they were needed most. This does not necessarily mean that these projects were simple priority-setting exercises. Multiple factors determine budget and management priorities, and the magnitude of risk is just one of those factors. The 1987 effort, in its systematic evaluation of relative risk, helped fill an important void. Then-EPA administrator Lee Thomas and other policy makers were provided a more thorough understanding of relative risks to human health and ecosystems: where they occurred geographically, how many people were potentially affected, and if any special populations were particularly susceptible.

The comparative risk tool has continued to evolve. State, regional, and local organizations agreed that reporting on relative risks would provide a sounder basis for their environmental management decisions. As a result, 24 states and more than a dozen localities have completed comparative risk projects during the late 1980s and 1990s. Projects have varied in their structure, scope of analysis, and the manner in which results have been used. Project sponsors have ranged from regional and state agencies to local nonprofit groups. Some projects relied on rigorous technical data to arrive at their rankings; other rankings were more discussion-driven. While every project has been unique, all of them expanded the discussion of environmental risk.

New Jersey's Comparative Risk Project was inspired by these other projects. In several ways, the sophistication of the comparative risk tool has grown, and its role in policy making today is better understood than when the EPA *Unfinished Business* report appeared. By facilitating a systematic evaluation of risks across problem areas, comparative risk provides a useful first step toward improving the use of risk information in environmental decision making.

Comparative Risk Is...

...An analytic exercise for estimating the relative harm from different environmental problems

...A structure for evaluating issues in a manner that reflects public values

...A useful mechanism for bringing risk information into the overall priority setting process

Caveats About Rankings

Comparing Apples and Oranges

Comparative risk is a highly structured **analytic exercise for estimating the relative harm from different environmental problems**. Traditional risk assessment methods characterize the degree of risk associated with a given "pollutant" at a known concentration, usually expressed as a probability. Comparative risk methods use the information from such assessments, along with other available information, to arrive at a relative score for each pollutant, and enabling them to be compared or ranked.

Comparing the risks of secondhand tobacco smoke with those of mercury is very much like comparing apples to oranges. Shoppers do this every day when deciding what fruit would be best for their purposes, if with some uncertainty and different people reaching different conclusions. Comparative risk relies on the selection of scoring and ranking criteria for making these types of comparisons. Project analysts review available data in a structured format that elicits key pieces of information for scoring. Examples of commonly used criteria for evaluating human health impacts include:

- Number of people exposed
- Severity of health effects
- Frequency of exposure

The consistent use of these kinds of criteria enables analysts to organize the information they obtain in a way that facilitates comparisons across issues.

A number of key decisions strongly influence the outcome of the analysis. Project participants determine the scope of the analysis and how it will be conducted. After the assessment is complete, decisions must be made regarding the ranking results and how to use them.

Decisions prior to the assessment:

- Who participates?
- How much do we spend?
- Which issues do we evaluate?
- What criteria should we use to evaluate impacts?

Decisions after the assessment:

- What are the relative risks?
- How do we report our findings?
- What are our next steps?

Public Values Guide Scientific Judgment

Common to all comparative risk projects has been the commitment to **evaluate issues in a manner that reflects acknowledged public values**. Risks cannot always be compared in a purely objective fashion, and projects have consistently attempted to develop scoring criteria in accordance with the relative importance of different factors held by members of the public.

While scientific evidence may be able to demonstrate that Problem A causes developmental effects in children and problem B accelerates deaths due to respiratory illness, it does not provide an answer for which problem is "worse." Comparative risk provides the structure for organizing the science (number of children with delayed neurological development, number of increased deaths among respiratory patients). The application of scoring criteria clarifies the value judgments being made in determining relative risks (total number of people affected, special populations affected). Project decisions regarding where the lines are drawn between lower versus higher risk scores reflect project and public values and ultimately determine relative risk within the context of the project (which should be ranked higher, Problem A or Problem B?).

Reflecting the values of the public is not the same as reflecting the perceptions of the public. A motivation for many comparative risk projects is to overcome misconceptions about the relative magnitude of risks posed by different environmental problems. A history of media coverage and political statements can distort the image that some people have about the frequency or severity

Comparative Risk Is Not...

...A simple formula for shifting resources from lower to higher ranked problems

...Scientists' personal opinions about relative risk or policy direction

of environmental problems. Comparative risk projects often uncover and organize information about environmental conditions that builds a stronger factual foundation for public discourse.

Relative Risk and Priority Setting

Many sponsors and participants in early comparative risk projects expected the process to redirect resources to higher risk areas. Confusion has sometimes occurred regarding the relationship between ranked risks and environmental management priorities. Comparative risk exercises serve to enhance understanding of the relative risks resulting from different human activities. **Most comparative risk project participants reject the use of their projects as a formula for shifting resources from lower to higher ranked problems**. Even though this was sometimes a desired outcome of early projects, the direct influence a single project can have on a complex system of environmental management priorities is limited.

There is a certain logic behind allocating agency resources to address higher risks. But a few factors make such conclusions practical in only rare cases. These include the limits of agency responsibility, differing costs of risk reduction, and the appropriate role of public opinion in policy making.

1. Agency responsibility is limited.

Environmental management agencies do not have statutory authority to eliminate the risk from all environmental threats. Natural sources of contaminants and indoor pollutants are examples where the public may be subject to relatively high levels of risk, but exposure is not regulated (and regulation may require legislative mandates). But environmental management priorities are shaped over long periods of time and driven by many factors besides risk. Comparative risk does, however, provide **a useful mechanism for bringing risk information into the overall priority setting process**. Risk rankings have also had some influence over where new resources are targeted, and have in some cases contributed to changes within program areas—how monitoring resources are allocated, for example.

2. Cost effectiveness of risk reduction varies.

Some environmental threats will require more money to address than will others. The allocation of public resources for risk management includes the consideration of cost factors in addition to the magnitude of risk. These resources may be spent on risks that can be significantly reduced, even if of lower threat.

3. Public opinion influences policy choices.

Environmental problems are often elevated to the policy arena as a result of public concern. Without a mechanism for evaluating and reporting relative risk, issues that generate more media or political attention may receive higher priority for policy making.

Opinion Versus Analysis

Comparative risk is not scientists' personal opinions about relative risk. While it would be easier to simply poll a group of scientists and report their opinions regarding the relative risks of different environmental issues, the resulting rankings would lack the analytic transparency of a comparative risk framework. Regardless of the outcome, the organizing framework and criteria chosen to establish relative risk provide the rationale for the resulting ranking. Of course, it is impossible to eliminate all subjective factors, but the characteristic consistency in the way problems are evaluated in comparative risk helps control the introduction of opinion into the analysis.

Relative Risk Versus Policy Analysis

Comparative risk does not provide a mechanism for evaluating the effects of past policies and programs to reduce risk. While ranking results may stimulate discussion about the effectiveness of the current policy mix, these results reflect residual risk—the risk that remains despite over thirty years of environmental management programs. This need not suggest a misdirection of resources; not all programs are established in response to a perceived need for risk reduction. Most environmental programs have been established as a result of federal or state legislative action, generally without considerations of risk relative to other types of threats. In many cases these efforts have reduced risks, while in others significant challenges remain.

The identification of priorities is not a straightforward task. The results of a single comparative risk exercise do not lead to a simple proclamation of environmental management priorities. However, the consideration of the range of impacts associated with different threats can serve to focus attention on a more comprehensive set of environmental issues and provide a stronger foundation for collaborative solutions.

Understanding the New Jersey Rankings

Comparative risk is a tool for using the best available science to answer the question, "What is the relative importance of recognized environmental problems?" By applying a consistent set of criteria to different stressors, comparative risk analysis enables a ranking of relative risk that can help inform one dimension of environmental management discussions.

Each of the Technical Working Groups applied its own criteria for analysis. Impacts were scaled according to the selected criteria, resulting in a structured evaluation of the relative magnitude of risks. The outcome of each TWG ranking was a direct reflection of the criteria and scales used in the analysis. Stressors that ranked highly were those that warranted higher scores based on these particular scales. Had different criteria been chosen by the Steering Committee, which oversaw the TWGs' work or different scales used, the ranking results may have looked different from those which appeared here. The comparative risk rankings were limited by other factors as well; a few of the major influences are described below.

Project boundaries

A thorough treatment of the universe of possible environmental risks in New Jersey would be a monumental task. In order to define a more manageable project, the Steering Committee agreed on some boundaries for the analysis. The resulting rankings reflect these boundaries, and it is important to keep in mind that some risks might not have been identified or might not have been considered appropriate to address in the context of this project.

Several stressors were excluded from analysis by <u>any</u> TWG, including such examples as:

• Occupational health stressors: Unless these were also important in environmental health, these chemicals were excluded as not affecting the general environment.

• Medical X-rays: Although these are regulated by DEP, they do not have an effect on the general environment (see Appendix 6 for an analysis completed before this decision).

• Natural hazards (flooding, drought, etc.): These were deemed too unpredictable in severity and frequency to estimate adequately, and their health and ecological effects were covered to some degree by analyses of more specific stressors (e.g., microbial pathogens, greenhouse gases).

• Non-point source pollution, and Erosion: These two stressors were addressed as appropriate for particular stressors (e.g., nitrogen, phosphorus, pesticides), but not as separate categories.

• Invasive plants: Ten of the "worst" species in New Jersey as suggested by a group of ecologists were the focus of analysis; resources did not allow separate analyses for the hundreds of species that fall into this category (this grouping did not differ from the plants' individual rankings).

• Gypsy moths: They occur in New Jersey, but were not a current threat when stressors were selected. As this report was being completed, an upswing in gypsy moth populations suggested they would pose a low but chronic cyclical problem.

• Tourism/recreation: Although these activities can have ecological impacts (e.g., personal watercraft on eelgrass; hiking on trails and associated areas), data were not available to estimate the degree of impact for any except off-road vehicles (ORVs).

• Tentatively identified compounds (TICs): By definition, too little is known about the identity, occurrence, or impact of these water-borne substances to evaluate their risks.

• Brownfields: The effects of these contaminated locations within urban areas were incorporated into discussions of land use change and specific contaminants, as appropriate. "Brownfields" are not themselves stressors as defined in this project (but see Appendix 6 for an analysis of their socioeconomic impacts, written before this decision).

The time frame selected for the analyses represents another boundary. The Steering Committee, agreed to include impacts that could occur within the next five years. This avoided uncertainty in longer-range forecasts, and the clearly defined time period provided consistency in the analyses. However, the resulting rankings may not reflect longer-term risks, such as those involving climate change due to greenhouse gases.

The human factor

Individuals may weigh complex factors of risk in different ways. The reporting templates used by the TWGs were designed to minimize these differences, but individual analysts were responsible for evaluating available data and applying the criteria. Different analysts may have had different interpretations of the data or drawn different conclusions regarding risk. Peer review within the TWGs and the Steering Committee, plus some external reviews, served to make the rankings more objective and consistent. In addition, extensive review by TWG chairs resulted in the rewriting of some assessments by their authors in order to maintain a common approach among the assessments. Despite the possibility that data may be viewed differently from person to person, the conclusions reached about relative risk provide a useful first step in considering future policy choices.

Snapshots in time

Comparative risk rankings represent a snapshot in time. The rankings reflect the state of scientific knowledge, exposure levels, risk management efforts, and professional judgment that exists today (most analyses for this project were written in late 2000 and the first half of 2001). Issues that ranked lower or higher within the bounds of this project might rank differently tomorrow, as new information becomes available or the nature of the threat changes. And new stressors can appear, as in the 2002 invasion of New Jersey by southern pine beetles, which damage pine forests. Because the ability to report on relative risk will always be imperfect, a definitive ranking is not possible. Nevertheless, the analysis conducted by the Technical Working Groups describes some clear differences in relative risk, and policy decisions need to be made. Information about relative risk, however imperfect and subject to change over time, offers an important consideration for these decisions.

Resource limitations and data gaps

Comparative risk analysis relies on the judgment of working group members given available data, resources, and time for completing assessments. For stressors for which there is sufficient scientific knowledge about the threat, along with documentation of exposure in New Jersey, analysts may have a high degree of confidence in assigning a score. Unfortunately, for many stressors there are gaps in knowledge regarding the nature of the threat (What are the effects of the stressor?) and/or exposure (To what extent are New Jersey populations or ecosystems exposed?). In these cases, working group members must apply "best professional judgment" and peer review in the determination of scores.

Stressors that received high scores characteristically reflected sound evidence of both the hazard and extent of exposure in New Jersey. While the confidence in each individual risk assessment may vary from stressor to stressor, issues assigned a high risk are typically well studied in terms of their adverse effects and there is sufficient evidence of the stressor in New Jersey populations or ecosystems. Assignment of a low risk, on the other hand, may reflect a number of different scenarios. The box below summarizes four possibilities to bear in mind when reviewing ranking results. The stressor summaries beginning on page 102 provide the TWGs' rationales for ranking.

Low Risk May Reflect...

... lack of statewide impacts.
Low ranking stressors may not pose a significant threat on a statewide basis, but may be causing substantial impacts in limited geographic, demographic or ecological areas of the state. Stressors may have localized effects that are quite severe, yet do not generate high scores relative to more widespread issues.

... good management.
Some stressors have low impacts today because of control strategies designed to control them. Risks could increase without such strategies.

... today's risk...but not tomorrow's.
Some stressors pose little or no threat today, yet high risks are possible in the future, particularly for biological stressors not yet established in New Jersey.

... a lack of data.
For issues not well studied, or for which little monitoring has been done in New Jersey, risk is typically ranked low. More data might show that the actual risk is higher.